OLLSCOIL NA GAILLIMHE
UNIVERSITY OF GALWAY

Semester 2 Examinations 2022/2023

Course Instance Code(s)	4BCT, 3BP, 4BP, 3BLE, 4BLE, 1OA, 1EM
Exam(s)	B.Sc. (Computer Science & Information Technology), B.E.(Electronic and Computer Engineering), B.E. (Electrical & Electronic Engineering)
Module Code(s)	CT420
Module(s)	Real-Time Systems
Paper No.	1
External Examiner(s)	Dr. Ramona Trestian
Internal Examiner(s)	Prof. Michael Madden *Dr. Michael Schukat

Instructions: **Answer Question 1 and 2 other questions.**

Duration	**2 hours**
No. of Pages	**4**
Discipline(s)	Computer Science
Course Co-ordinator(s)	Dr. Colm O'Riordan

Requirements:

Release in Exam Venue	Yes [X]	No [ ]
MCQ Answersheet	Yes [ ]	No [X]
Handout	None	
Statistical/ Log Tables	None	
Cambridge Tables	None	
Graph Paper	None	
Log Graph Paper	None	
Other Materials	None	
Graphic material in colour	Yes [ ] No [X]	

Question 1 (Compulsory)

a) The exploration and colonisation of the moon in coming decades will require robust lunar navigation services as well as systems for accurate time keeping on the moon. Describe in some detail, how a satellite-based GNSS (similar to GPS) could be implemented to provide such services. In your answer also explain how multilateration, both alone and in combination with differential GPS (DGPS), would allow for accurate lunar navigation. Finally argue why or why not DGPS would be a necessity for accurate lunar navigation.

[6 marks]

b) Using an example consisting of three processes that share some resources, explain in detail how the **Priority Ceiling Protocol** prevents a deadlock situation.

[7 marks]

c) Construct a task schedule, consisting of 4 tasks, that is **EDF schedulable**, but NOT **RM schedulable**. Validate your design by calculating

a. the overall Utilisation U
b. the task timeline
c. an RM Schedulability Analysis

[7 marks]

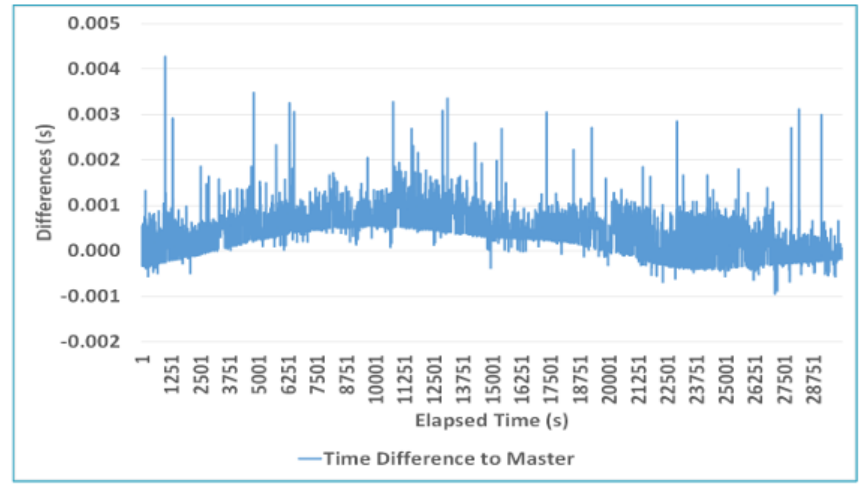
PTO

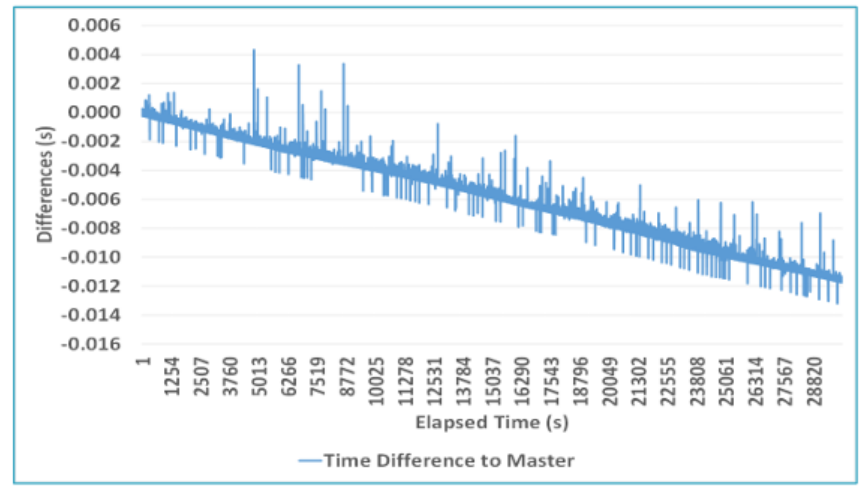
Question 2

a) Summarise the main features of **POSIX.4 signals**. Further on, outline the purpose and functionality of the function:
int sigqueue(pid_t pid, int sig, const union sigval value);

[8 marks]

b) The two diagrams below show the time difference between a UTC reference and two unsynchronised local clocks with quartz-based oscillators over a 24 hours period. Explain how such oscillator-based computer clocks work, and, ignoring the outliers in both diagrams, identify the causes for the clocks' behaviour as shown below.





[4 marks]

c) Distinguish between the terms **perfect network** and **deterministic network**. Argue why or why not (1) a standard Ethernet LAN and (2) a Wifi network can be deemed to be either one or the other.

[3 marks]

PTO

Question 3

a) Using an example explain how the **Berkeley clock synchronisation algorithm** works. Further on, argue why or why not this algorithm can be used to synchronise clocks in a distributed system to UTC time.

[5 marks]

b) Distinguish between RAID-0, RAID-1 and RAID-5, commenting on their characteristics and I/O performance.

[4 marks]

c) While cyclic executives are well suited to control hard real-time systems, their performance, i.e. timely execution of tasks, may be negatively impacted by asynchronous interrupts. Explain this phenomena and suggest methods to detect or mitigate such situations. Use code snippets to support your answer.

[6 marks]

Question 4

a) Using an example explain the inner working and limitations of **Lamport's logical clocks**. Further on, expand your example to show why **vector clocks** provide a better alternative.

[5 marks]

b) Hardware timestamping, transparent clocks, as well as the P2P delay calculation mechanism are some of the outstanding features of the PTP time synchronisation protocol. Using an example (that entails a network diagram, as well as all relevant PTP messages and timestamps exchanged), show how all these mechanisms work hand-in-hand to provide the accurate offset calculation of a slave clock against a grandmaster clock.

[7 marks]

c) Explain the term **backward recovery** (as used in the context of dynamic software redundancy), and, using code snippets, show how this approach can be implemented / emulated in Java.

[3 marks]